Case Study of Labor Costs and Efficiencies in Warehousing

FORMULA FEEDS

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PREFACE

The study on which this report is based is a part of a plan for a complete analysis of warehousing efficiency in mills manufacturing mixed feeds. The research represents part of a broad program to help reduce costs of marketing farm products.

This study was conducted by Richard Muther and Associates, Consultants in Industrial Management, Kansas City, Mo., under contract with the United States Department of Agriculture. The same contractor also conducted time and motion studies of the warehouse operations in the same mills, under contract with the Midwest Feed Manufacturers' Association. In view of the coordinated nature of the studies, the Midwest Feed Manufacturers' Association has agreed to make some of their data available to the Department for further analysis and a possible later report.

The authors acknowledge the assistance of the Midwest Feed Production School Committee in planning and organizing this study.

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CASE STUDY OF LABOR COSTS AND EFFICIENCIES IN WAREHOUSING FORMULA FEEDS

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SUMMARY

In a case study of materials handling in 6 feed mills having a daily volume of 100 tons per day, manual handling consumed about 45 percent of the average worker's time, transport about 26 percent, and idle or delay time about 29 percent. More than three-fourths of the idle or delay time resulted from occurrences beyond the control of the worker. The remaining portion was found to be within the usual allowance for personal requirements and necessary relaxation.

On the average, warehouse labor handled about 4 tons of bagged feed per man-hour.

The forklift truck handling method appeared to be the most efficient, and the hand truck method the least efficient in the use of labor. This finding must, of course, be related to the conditions in the case study mills. The belt conveyor warehouses shipped about 55 percent of the feed handled direct from the bagging area to the rail car or truck. The hand truck warehouses had about 26 percent in this type of shipment and forklift warehouses about 11 percent.

The average number of bag sizes handled per day was about the same in the three types of warehouse operations. Warehouses using hand trucks handled a slightly larger number of items and belt conveyor warehouses a slightly smaller number of items than did the forklift warehouses.

Basic handling methods in the forklift and hand truck warehouses are similar and require that a relatively small portion of the labor force be tied up in delivering bags from the packer. The conveyor system requires that a relatively high proportion of its labor force be used in delivering bags from the packer. Since a large portion of the idle or delay time was caused by changeovers, intermittent work flow, and waiting for the previous operation, more delay time is involved in the conveyor operation.

Many factors must be considered in determining the most efficient method of handling bagged feed in the warehousing operation. The total volume, proportion of direct shipments, warehouse layout, wage rates, capital investment, and the rate of depreciation certainly must be considered in addition to the relative efficiency in the use of labor. However, with labor accounting for about 69 percent of the total costs of operating a warehouse, a study of labor efficiency and efficiency in the use of labor should help management make decisions to improve this efficiency in existing plants as well as help it choose the type of material handling method for a new warehouse.

INTRODUCTION

The primary objective of this study was to analyze the relative efficiencies in the use of warehouse labor by feed-mixing mills and how this efficiency varies among mills using three basic warehouse materials handling methods.

In accomplishing this objective, considerable related information was obtained, such as:

(1) The relationship between total costs and certain component cost elements in the mill and in the warehouse.

(2) Volume and variety relationships, including bag sizes, form of feed, and formula changes.

(3) Variations in movement of feed into and through the warehouse.

(4) The proportion of time spent in various warehouse operations.

A study of labor costs and efficiency, primarily based upon physical inputs, does not consider all of the factors that management uses in making a decision to invest in any specific type of warehouse equipment. For example, it does not consider the possibility that within any given area the wage rates for the labor used in one type of materials handling method may be relatively cheaper than that used in another method. The relative capital investment and depreciation costs must also be considered. However, in view of the fact that labor represents about 69 percent of the total costs of operating a warehouse in the formula feed industry, a study of labor inputs should be helpful to management in making these decisions.

This survey of labor costs and efficiency involves a case study of 6 plants considered by industry men as relatively typical of the respective types of operations. The contractor reviewed the warehousing operations of about 25 plants in deciding which ones to use in the case study. The plants selected are located in the Midwestern part of the United States and therefore specifically represent Midwestern operations during the months of June, July, and August. However, a majority of the findings will be applicable, with minor adjustments, to similar operations in other areas of the country and other times of year. In addition, the plants chosen for study represent plants mixing approximately 100 tons of formula feed per 8-hour day. Therefore, this report will give only indications or guides for plants mixing either 50 or 200 tons per day. The least efficient method in the plants studied may therefore prove to be the most efficient for either a larger or a smaller operation.

METHODOLOGY

Six mills were studied during the months of June, July, and August, 1957. Two mills were chosen because their warehousing operation was performed primarily by forklift trucks and pallets. Another 2 because their operation was primarily through the use of a belt conveyor. The remaining 2 were chosen because their warehousing operation was performed by 2-wheel hand trucks.

The first step in each plant was to obtain annual costs and volumes. These costs and volumes were obtained for comparable cost breakdowns and production items for the preceding 12-month accounting period. In reality, this became the 1956 calendar year in practically all cases.

The second step in each plant was to arrange for work sampling to determine the amount of time used to perform a given task with different handling methods. Comparable 8-hour-day production-variety data were obtained for each mill.

The third step involved work sampling observations for three 8-hour days in each plant. A consecutive Tuesday, Wednesday, and Thursday were chosen in each case and a continuous circuit of observations was taken. The observations were continuous during the 8-hour day, although some plants had scheduled breaks for cigarettes and relaxation and others did not. Observations were made at a series of operating points and were made on a worker basis rather than a functional or an operation basis. 1/ The observer changed his route periodically in order to minimize the influence on the workers. He made a snap observation of each man's work status at each visit to a prescribed station although, after the immediate observation, he frequently required some time to record his determination.

Since work sampling technique is a statistical method, the reliability of these data depends upon the number of observations recorded. The greater the number of observations and the larger the proportion of the activity to the whole, the more reliable the data. Consequently, some of the reported data will be more reliable than others. Actually, however, a large number of observations were made per plant per day and, since the 3-day averages were used throughout the report and in many cases the 2 plants with similar procedures were combined, the universe consisted of nearly 1,200 observations of each type of materials handling method employed. 2/

1/ This choice was made partially to supplement rather than duplicate the Midwest Feed Manufacturers' Association's time and motion analyses in these same mills.

2/ Only in one plant having a sizable business in bulk during the 3 observation days did the number of observations drop to a lower level because of the smaller warehouse crew.

ANNUAL OPERATIONS

Annual costs and volume-variety data were obtained to gain necessary information about each mill prior to the materials handling study and also to permit an analysis of the representativeness of the 3-day information.

These annual data are the best estimates that could be made on the basis of existing cost and volume records. Mill accountants and mill managers made the estimates when specific records were not available. They are believed to be entirely adequate for the purposes intended. 3/

Definition of Terms

Mill operating costs include all the costs of operating the formula feed mill but exclude costs of material and ingredients and inbound freight, selling expenses (including delivery and advertising), and general administrative expenses (including experimental farms and similar activities).

Warehouse operating costs include handling, storing, and shipping, i.e., everything from the completion of bag sewing to the movement of the truck or rail car from the warehouse or mill. Also included are the costs of handling ingredients and bulk feed when these are part of the regularly assigned duties of the warehouse working force.

Direct labor costs are payments to employees working directly on the product.

Indirect labor costs are payments to employees such as janitor, watchman, shipper, order-writer, clerk, and maintenance man.

Supervision costs are payments to employees such as foreman, superintendent and mill manager.

Other labor costs are payments for items such as taxes, employee benefits, first aid, worker's compensation charges, and overtime premiums.

Total Operating Costs

Total operating costs in the 6 mills averaged $6.96 per ton produced. The total warehouse operating cost per ton of feed shipped averaged $1.58 and ranged from $1.37 to $1.82. This variation in total warehouse costs was greater than that in total mill costs.

3/ Although these data do not conflict with other published average cost and volume information, they should not be viewed as industry averages since they merely represent case study data.

Labor Costs

Labor accounts for about 53 percent of the total mill operating costs and 69 percent of the total warehouse costs (table 1). Direct labor expenses account for more than two-thirds of the total labor costs incurred in both the mill and the warehouse (table 2). The warehousing operation requires its share of supervision and other labor costs but somewhat less indirect labor expenses.

Table 1.--Distribution of annual mill and warehouse operating costs, by cost element

Cost element	Operating costs: Mill		Operating costs: Warehouse	
	Percent		Percent	
Direct labor	34.0		47.0	
Indirect labor	7.1		5.7	
Supervision	5.6		6.9	
Other labor	6.8		8.8	
Total-Operating labor		53.5		69.3
Repairs, rents, and depreciation	24.2		12.4	
Other operating costs	13.8		7.2	
Management and administration	8.5		11.1	
Total-Other		46.5		30.7
Total costs		100.0		100.0

Table 2.--Annual mill and warehouse labor cost, distribution, and relationship, by cost element

Cost element	Proportion of total labor cost devoted to: Mill	Proportion of total labor cost devoted to: Warehouse	Warehouse as proportion of mill cost by classification
	Percent	Percent	Percent
Direct labor	64	69	30
Indirect labor	13	8	17
Supervision	10	10	26
Other	13	13	27
Total	100	100	27

The warehouse requires about 30 percent of the total direct labor and 27 percent of the total labor expenses (table 2).

Mill labor costs averaged $3.72 per ton produced or about 53 percent of the total mill operating costs. Direct labor costs account for $2.36 per ton produced.

Warehouse total costs averaged $1.47 per ton produced and $1.58 per ton shipped (table 3). 4/ Direct labor costs averaged $0.71 per ton produced and $0.75 per ton shipped. The range for these direct labor costs was surprisingly small (table 3).

Table 3.--Annual unit operating cost for warehouse by cost element

Cost element	Average cost per ton produced	Cost per ton shipped		
		Average	Range	
			High mill	Low mill
	Dollars	Dollars	Dollars	Dollars
Total costs	1.47	1.58	1.82	1.37
Total labor	1.02	1.09	1.35	.82
Direct labor	.71	.75	.82	.68

Volume-Variety Information

The feeds produced by modern mills differ substantially in both appearance and content. Appearance is partly affected by the form of the feed (mash, pellet, etc.) and by the type and size of container or its bulk condition. The content of the feed depends on the particular formula upon which it was mixed. The diversity of items creates problems in production and especially in warehousing.

The number of formulas produced annually in the 6 mills was 498 for an average of 83 formulas per mill. The minimum number of formulas in any mill was 55.

The average number of tons produced per formula per year was 445. However, it is even more significant that in the average mill 10 percent of the formulas accounted for about 65 percent of the total tonnage (fig. 1). At the other extreme about 31 percent of the formulas account for only 1 percent of the total tonnage.

4/ The difference in tons produced and shipped is accounted for by the fact that some shipments bypass the warehouse.

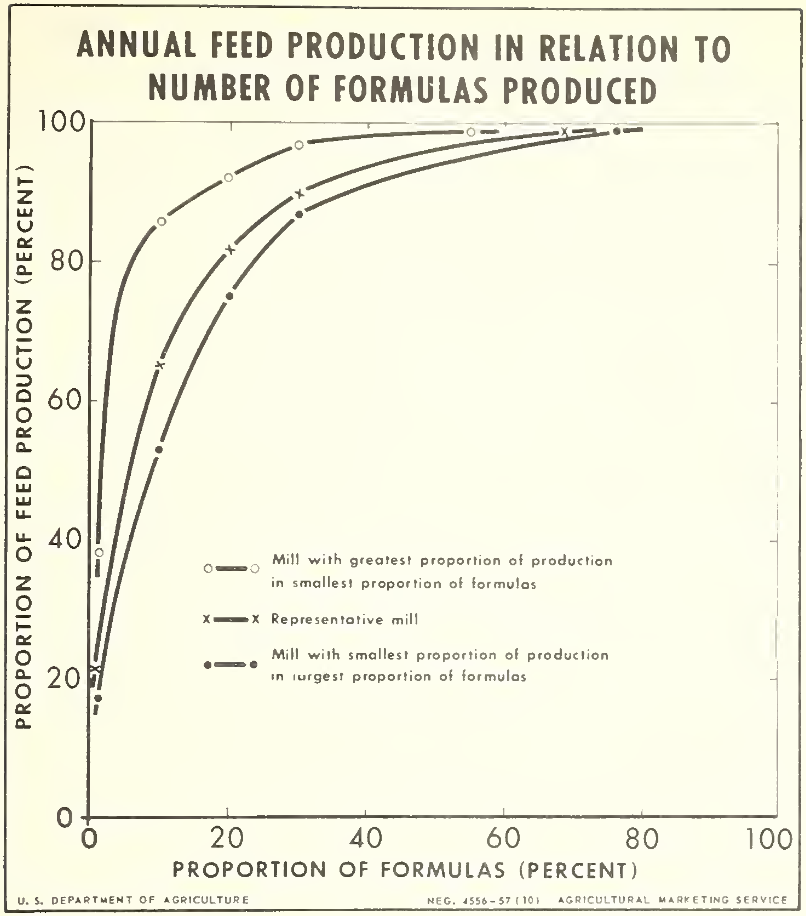

Figure 1

The form of the feed was classified as: Mash and meal, pellets and cubes, and crumbles. These simple categories were used to reduce complications since there are many slight differences in form of product. Table 4 indicates that volume was split fairly evenly among these categories.

The bulk and bagged volumes in the average plant were 11 and 89 percent respectively (table 4). Volume bagged ranged from 100 percent in one mill to 60 percent in another.

Bag sizes ranged from 25 to 128 pounds. No attempt was made to analyze the minor smaller sizes for miscellaneous products. These smaller sizes accounted for less than one-half of 1 percent of the total tonnage.

The 50-pound bag was by far the most popular size, followed by the 100-pound and 25-pound bags (table 5). The average warehouse handled 1,211,000 bags during the year. The average number of bags per ton did not vary significantly among the 3 types of mills (table 5).

Table 4.--Annual distribution of production and form of feed by material handling method

Material handling method	Production: Bagged	Production: Bulk	Production: Total	Form: Mash and meal	Form: Pellets and cubes	Form: Crumbles	Form: Total
Fork lift	87	13	100	25	47	28	100
Hand truck	97	3	100	33	40	27	100
Conveyor belt	83	17	100	33	36	31	100
Average	89	11	100	31	40	29	100

Table 5.--Annual distribution of bag size, average number of bags used by handling method, and number of mills using bags of specified sizes

Handling method	Size of bag (pounds): 25	50	75	80	96	100	128	Total	Average bag sizes used	Number of bags per ton of feed
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	No.	No.
Fork lift	1/	34	0	0	0	5	0	39	3.0	37.7
Hand truck	1	19	0	1/	1/	10	1/	30	4.5	34.6
Conveyor belt	2	20	1/	1	0	8	0	31	4.0	37.1
Total	3	73	1/	1	1/	23	1/	100	3.8	36.5

1/ Less than 1 percent.

Number of formulas and bag sizes are summarized in table 6. Approximately 79 percent of the formulas are packed in only one bag size.

Number of items produced averaged 132 per mill ranging from a high of 289 items in one plant to 75 in another. An item is defined as the total variety of formulas or brands in any feed form and in any bag size including bulk.

For every 5 formulas produced in these mills, there is an average of 6 bag-size and formula variations and 8 items. Thus, each time a mill produces a new formula, 1.6 new items or varieties are added. This multiplier becomes very important in a warehouse operation and should be considered by formula feed mill management and the sales force. Unless this multiplier is recognized, the addition of formulas and brands may crowd warehouse space and decrease warehousing efficiency more than anticipated.

The type of transportation used was divided almost equally between rail and truck. All mills use both types of shipment.

Table 6.--Annual number of formulas by bag size

Bag size	Number of formulas		Percent of total formula	
Single bag in pounds:				
25	8		1.6	
50	299		60.5	
75	1		.2	
80	2		.4	
96	1		.2	
100	83		16.6	
128	1		.2	
Total		1/ 395		79
Multiple bag in pounds:				
25 & 50	7		1.4	
25, 50, & 100	15		3.0	
25, 50, 80, & 100	2		.4	
25 & 100	3		.6	
50 & 80	11		2.2	
50, 80, & 100	4		.8	
50 & 100	51		10.2	
Total		93		19
Bulk only 2/		10		2
Total formulas		498		100

1/ Fifty-four of these formulas were shipped in bulk as well as in bags; 341 were shipped in bags only.

2/ Other formulas packed in both bags and bulk are included in the bag sizes listed.

THREE-DAY VOLUME, VARIETY, AND MOVEMENT

The 3-day study in each plant, during the summer season, appears to be fairly representative of average annual 8-hour-day operations.

Production per 8-hour day during the 3-day study ranged from about 60 tons in the plant producing the least to 180 tons in the plant producing the most. It averaged 112 tons per plant. If the mills were operated 260 days per year, the average plant would produce about 29,000 tons per year. Based on the preceding annual average, the average plant produced 36,000 tons. The fact that the estimates are so close is primarily due to the obtaining of Tuesday, Wednesday, and Thursday data during the summer season. These 3 days are normally the top production and shipping days during a week. The difference between the 3-day volume and the annual volume can primarily be explained by either (1) the use of a longer workday during peak seasons, or (2) the use of a second shift during the peak season.

Annual production records for the 6 plants indicated shipments were composed of 31 percent, mash and meal; 40 percent, pellets and cubes; and 29 percent, crumbles. The 3-day production is summarized in table 7 and the above items range from 31 to 36 percent for the average mill.

The annual production records indicate that 89 percent was shipped in bags. Three-day production records indicate that 92 percent was shipped in bags.

Table 7.--Proportion of total production and shipment by form and container, 3-day average

Item	Production average	Shipments		
		Average	High volume mill	Low volume mill
	Percent	Percent	Percent	Percent
Mash and meal:				
Bags	30.5	35.8	24.4	28.8
Bulk	5.5	1.2	1.6	0
Pellets and cubes:				
Bags	28.6	31.7	29.7	40.0
Bulk	4.4	4.3	14.3	0
Crumbles:				
Bags	25.0	24.2	23.8	31.3
Bulk	6.0	2.8	6.2	0
Total:				
Bags	84.0	92.0	78.0	100.0
Bulk	16.0	8.0	22.0	0
Total	100.0	100.0	100.0	100.0

Annual production records indicate that 73 percent of the feed was bagged in 50-pound bags, with 100-pound and 25-pound bags being second and third respectively. The same general picture appears for the average plant during the 3-day period (table 8).

Table 8.--Proportion of total production and shipments in various bag sizes, 3-day average

Bag size in pounds	Production average	Average shipments	Range of shipments: High mill	Range of shipments: Low mill
	Percent	Percent	Percent	Percent
25	4.1	4.2	19.0	1/
50	67.3	76.7	99.0	4.0
80	2.8	2.1	10.0	1/
96	.0	1/	1/	1/
100	9.8	10.6	49.0	3.0
128	.0	1/	3.0	0
Bulk	16.0	6.4	22.0	0
Total	100.0	100.0	---	---

1/ Less than 1 percent.

Annual records, however, indicate a much different picture than does the 3-day period for the numbers of formulas produced. In view of (1) the seasonal nature of the demand for specific feeds, and (2) the greater efficiency of longer production runs on each specific formula, it is expected that a much smaller number of formulas will be shipped and, especially, produced during any given 3-day period. The number of formulas produced and shipped during the 3-day period appears in table 9. The annual average number of formulas produced and shipped per plant was 83.

All feed coming from packing goes to one of two places: Into warehouse storage or direct to a vehicle for shipment. This is all handled by the warehouse crew. In addition, the same crew moves feed from the warehouse storage to a vehicle for shipment. Consequently, the amount of feed moved cannot be determined from production figures only or shipping figures only.

For a true picture of the actual amount of feed moved, and to determine the tonnage actually handled per man, the combination of quantities must be considered. The movement of feed handled or rehandled gives the true total of the amount of feed actually moved.

The direction of feed flow in the warehouse in proportion to the total feed handled or rehandled is summarized in table 10. Attention is called to the amount directly loaded by the conveyor belt method. The total shows 55 percent, quite a bit higher than either of the other methods. Obviously, however, an additional materials handling method is necessary with the belt method, under these conditions. Of the two mills that used the conveyor belt handling method, one also used hand trucks while the other used forklift trucks in conjunction with its conveyor belts.

Table 9.--Number of formulas, feed forms, and items produced and shipped, and number of changeovers, 3-day average

Item	Produced average	Average	Range in items shipped: High mill	Range in items shipped: Low mill
	Number	Number	Number	Number
Formulas 1/	9	25	32	14
Feed forms 2/	10	27	35	16
Items 3/	12	30	38	17
Changeovers 4/	10	---	---	---

1/ A formula indicates one specific feed.
2/ Feed form is the physical form of the feed. The same formula may be manufactured in any of the three forms used for recording: Mash, pellets, or crumbles.
3/ Item is a packaged feed. The same formula--in any of its three forms--may be packed in more than one size bag or may be shipped in bulk. Each variation is an item.
4/ A changeover occurred when a different formula was mixed.

Table 10.--Direction of feed flow in the warehouse in proportion to the total feed handled or rehandled, 3-day average

Movement	Fork-lift plants	Hand truck plants	Conveyor belt plants	Average plant	Range in feed flow: High mill	Range in feed flow: Low mill
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Direct from packing to rail car	8	23	43	21	57	0
Direct from packing to truck	3	3	12	4	38	1/
Packing to warehouse storage	37	47	27	39	51	20
From warehouse storage to rail car	14	6	7	9	28	0
From warehouse storage to truck	38	21	11	27	51	10
Total	100	100	100	100	---	---

1/ Less than 1 percent.

ANALYSIS OF LABOR ACTIVITIES

The activities observed during the work-sampling study can be divided into three basic categories:

(1) Manual handling--the task is done by the worker using his hands or body.

(2) Transportation--the worker's time is spent in operating or propelling a piece of equipment used to move material.

(3) Idle or delay time--the time that the worker is waiting, dawdling, or not engaged in productive work, whether within or beyond his control.

Manual handling operations consumed about 45 percent of the average warehouse worker's time, transport about 26 percent, and idle or delay time 29 percent (table 11).

Table 11.--Six mill comparison of average, and range of time for basic worker activities, 3-day average

Basic category of worker activities	Average percent	Range: High mill: Type of operation	Range: High mill: Percent	Range: Low mill: Type of operation	Range: Low mill: Percent
Manual handling time	45	Forklift	56	Hand truck	32
Transport time	26	Hand truck	38	Conveyor	18
Idle or delay time	29	Conveyor	38	Forklift	22
Total	100		---		---

Manual Handling

Manual handling includes warehouse operations such as loading; unloading; checking, preparing, and closing cars; handling incoming ingredients; cleanup and other work. Unpiling and stacking are included in the load and unload categories respectively.

On the average, about one-third of the time used in this manual operation is spent in a loading status and another one-third in an unloading status (table 12). A majority of the time remaining was spent in cleanup and other work. These observed times varied considerably according to type of operations.

The time workers spent in each of these work categories in forklift, hand truck, and conveyor warehouses appears in table 13. A relatively smaller proportion of the warehouse workers' total time is spent in these manual operations in a hand truck warehouse.

Table 12.--Six mill comparison of the average and range of time devoted to manual handling activities, 3-day average

Activity	Average percent	Range: High mill: Type of operation	Range: High mill: Percent	Range: Low mill: Type of operation	Range: Low mill: Percent
Load (incl. unpile)	33	Hand truck	50	Conveyor	11
Unload (incl. stack)	31	Forklift	41	Conveyor	21
Prepare, close car, and check	10	Conveyor	16	Hand truck	7
Handle ingredients	5	Conveyor	18	Hand truck	0
Cleanup and other work	21	Conveyor	43	Conveyor Hand truck	9
Total	100		---		---

Table 13.--Proportion of workers' time devoted to manual handling activities by handling method, 3-day average

Activity	Forklift: Proportion of: Manual handling time	Forklift: Proportion of: Total observed time 1/	Hand truck: Proportion of: Manual handling time	Hand truck: Proportion of: Total observed time 1/	Conveyor belt: Proportion of: Manual handling time	Conveyor belt: Proportion of: Total observed time 1/
	Percent	Percent	Percent	Percent	Percent	Percent
Load (incl. unpile)	30	14.8	54	21.1	20	9.5
Unload (incl. stack)	36	17.6	25	9.7	31	14.5
Prepare, close car, and check	11	5.2	9	3.4	12	5.8
Handle ingredients	6	2.8	2	.9	9	4.0
Cleanup and other work	17	8.3	10	4.1	28	13.1
Total	100	48.7	100	39.2	100	46.9

1/ Proportion of total observed time spent in the warehouse operation including manual, transport, and idle or delay time.

The load and unload activities are approximately the same for the forklift and hand truck methods of handling.

The conveyor belt direct handling method shows less combined load and unload activity. This is to be expected since with the other two methods a greater proportion of the output is stored in the warehouse before shipment, thereby requiring double handling.

Transportation

Transportation time includes transporting direct to the car or truck, into the warehouse, from the warehouse to the car or truck, relocating items in the warehouse, and returning empty. The largest proportion of the average worker's transport time (for any one action) is used in returning emptyhanded from the rail car, truck, or warehouse (table 14). More than one-third of his time is spent in this manner. A return trip is necessary for each of the other categories of work. The next most important categories, in view of time spent, are transport from warehouse to truck and transport from plant or platform to warehouse. Again, each different type of warehouse operation requires a considerably different allocation of the warehouse worker's time.

The allocation of warehouse worker's time in the forklift, hand truck, and conveyor belt warehouses is shown in table 15. The transportation time for the conveyor system is obviously much less than that for either of the other handling methods. In conveyor plants, workers used only about 17 percent of their time in transportation operations, in forklift plants about 26 percent, and in hand truck operations about 33 percent of their total time.

Obviously, transporting direct with the conveyor belt method involves no worktime for the warehouse employees. However, in the case of the largest producer using this system 42 percent of the transportation time, or 12 percent of the total observed time, was consumed in walking from the conveyor belt chute with a bag, or returning to the chute for the next bag.

Since the workers observed were able to keep up with the stream, this walking time does not appear critical. However, as faster packing equipment is developed it may well be necessary to devise a system that will eliminate or substantially reduce the necessity for carrying a bag from the chute to its final location in the car or truck. A portable, extendable conveyor that can be rapidly adjusted and moved might be advisable to eliminate this excessive walking.

The addition of manual and transportation time will not yield any valid efficiency observations other than those which will be noted in the next section when the residual and idle or delay time are analyzed. The proportions of the total worktime spent in the different types of operations are important but are influenced to a large extent by the conditions encountered in the survey.

Critical analyses or comparisons of the data presented up to this point must be tempered somewhat since they do not reflect the amount of work accomplished while in a work status.

Table 14.--Proportion of workers' time devoted to transportation activities, 3-day average

Transport activity	Average	Range in proportion of workers' time			
		High mill		Low mill	
		Type of operation	Percent	Type of operation	Percent
Direct to rail car	13	Hand truck	20	Conveyor	0
Direct to truck	1	Forklift	4	Conveyor	0
To warehouse	20	Hand truck	32	Forklift	8
From warehouse to rail car	7	Conveyor	26	Hand truck	1
From warehouse to truck	21	Forklift	33	Hand truck	14
Relocate in warehouse	6	Conveyor	32	Hand truck	0
Transport empty	32	Conveyor	48	Conveyor	21
Total	100	---		---	

Table 15.--Proportion of workers' time devoted to transportation activities by handling method, 3-day average

Transport activity	Forklift		Hand truck		Conveyor belt	
	Proportion of		Proportion of		Proportion of	
	Transportation time	Total observed time 1/	Transportation time	Total observed time 1/	Transportation time	Total observed time 1/
	Percent	Percent	Percent	Percent	Percent	Percent
Direct to rail car	6	1.7	17	5.7	0	0
Direct to truck	3	.7	1	.2	0	0
To warehouse	12	3.2	30	10.2	16	2.8
From warehouse to rail car	8	2.1	3	.9	16	2.8
From warehouse to truck	28	7.2	19	6.4	24	4.0
Relocate in warehouse	7	1.7	0	0	15	2.6
Transport empty	36	9.5	30	10.5	29	5.0
Total	100	26.1	100	33.9	100	17.2

1/ Proportion of total observed time spent in the warehouse operation including manual, transport, and idle or delay time.

Idle or Delay Time

Nine different types of delay time were analyzed (table 16). Three of these, changeover, intermittent work flow, and waiting, were difficult to separate. 5/ Fifty-five percent of all delay time was accounted for by these three classifications.

Table 16.--Delay time in 6 mills in order of magnitude, 3-day study

Activity	Percent of delay time	Percent of total observed time
Changeover delay) Intermittent work flow) ... Waiting for previous operation)	55	16.2
Miscellaneous	12	3.6
Breaktime (rest period)	12	3.5
Job reassignment	9	2.5
No reason	5	1.4
No car or truck	4	1.2
Absent	3	1.0
Total	100	29.4

The next largest reasons for delay were miscellaneous delays and breaktime or rest periods. At one mill, job reassignment was responsible for 24 percent of the delay. This was unusual, however, since it represents a situation where frequent job changes and considerable movement were required. The remaining reasons represent only a small percentage of the total observations and are given separately primarily to show their minor importance. It must be remembered that a total of about 3,300 observations were obtained in the study.

The classification of idle and delay time which has proved to be most valuable is:

1. Idle time outside the control of the worker.

2. Idle time within the control of the worker.

5/ For example, a worker moving bags from the takeoff table to a pallet could be idle because of the intermittent flow of bags. This intermittent flow could in turn be caused by a changeover, if more than one line was feeding the same takeoff table.

Many people contend that all categories of idle or delay time are within the control of the worker since it is the practice in most mills to expect workers to sweep and do housekeeping work when lack of work occurs. However, many of the delays which are beyond the control of the worker are individually of such short duration that performing another task is impractical if not impossible.

A striking example of delay time is that resulting from the uneven flow of bags coming from the packing machines to the takeoff table. It is important that the worker stay close to the takeoff table to remove the bags as they arrive. Since he has no means of knowing when the next bag is coming until it is practically there, he frequently has periods when he contributes nothing productive but cannot go to another location to do productive work.

Although the individual delays are of such short duration that other activities are impractical, these delays are frequently so numerous that a considerable amount of total time is lost.

Detailed breakdowns of delays are given in tables 17 and 18. 6/

Delays outside workers' control.--On the average, almost three-fourths of the delay time was outside the control of the worker (table 17). In the plant having most delay time, 91 percent of it was in this classification. In the plant with the least, 70 percent.

Obviously, little or nothing can be done by the worker to reduce the number of delays. This is solely the responsibility of management.

It is often said that delays cannot be helped; it is the nature of the business. Regardless of how justified this argument may be, passing off lost time in this manner contributes nothing to the solution. Constant vigilance by management should be the rule and every effort made to reduce this lost time.

Delays within workers' control.--Delays in this classification also can be controlled by close supervision. However, a certain number are to be expected for such things as personal requirements and fatigue. A figure generally accepted throughout industry for such delays is 9 to 11 percent of total time; for excessively fatiguing work 13 to 17 percent is deemed reasonable. 7/ Tables 17 and 18 indicate that nearly all of the 6 plants remained in or below this range. The average of the hand truck plants was 4.8 percent, fork truck plants 7 percent, and conveyor plants 10.6 percent of total workers' time in delays within his control.

6/ A total of about 1,200 observations were made in each type of plant to provide a representative picture of the workers' activities during the day.

7/ Industrial engineers will recognize these figures to be the same as the usually accepted allowance of 10 to 12 percent of the base leveled time, or 15 to 20 percent for excessively fatiguing work, exclusive of unavoidable delays.

Table 17.--Proportion of workers' time spent in idleness and delays, 3-day average

Activity	Average	Range in proportion of delay time in each activity			
		High mill		Low mill	
		Handling method	Delay time	Handling method	Delay time
	Percent		Percent		Percent
Outside workers' control:					
Wait for car or truck	4	Hand truck	21	Several	0
Wait for changeover	7	Conveyor	22	Forklift	1
Intermittent work flow	17	Hand truck	35	Forklift	6
Wait for previous operation	31	Forklift	55	Conveyor	15
Job reassignment	9	Conveyor	24	Hand truck	1
Miscellaneous 1/	6	Conveyor	13	Forklift	3
Total	74	Hand truck	91	Conveyor	70
Within workers' control:					
No reason	5	Conveyor	13	Hand truck	0
Absent	3	Conveyor	6	Hand truck	1
Breaktime	12	Forklift	21	Conveyor) Hand truck)	0
Miscellaneous 1/	6	Conveyor	13	Forklift	3
Total	26	Conveyor	30	Hand truck	9
Total	100		---		---

1/ Miscellaneous time was divided equally between outside control and within control of the worker.

One factor contributing to this relatively low "within worker control" delay is the delay time in "outside worker control." For the plants analyzed, the workers used some of this delay time for personal requirements and other activities normally found in the "within worker control" delay.

Comparison by Handling Methods

A most interesting comparison (table 18) indicates that while a little more than one-fourth of the total workers' time is delay time, in the forklift and hand truck warehouses, more than one-third of the workers' time in conveyor warehouses is in this category.

Table 18.--Proportion of workers' time spent in idleness and delays, by handling method, 3-day average

Activity	Forklift		Hand truck		Conveyor belt	
	Delay time	Total observed time	Delay time	Total observed time	Delay time	Total observed time
	Percent	Percent	Percent	Percent	Percent	Percent
Outside workers' control:						
Wait for car or truck	0	0	9	2.5	3	1.0
Wait for changeover	5	1.3	2	.5	13	4.6
Intermittent work flow	15	3.7	28	7.5	11	3.8
Wait for previous operation	44	11.2	36	9.7	17	6.2
Job reassignment	5	1.3	1	.4	16	6.0
Miscellaneous 1/	3	.7	6	1.5	10	3.7
Total	72	18.2	82	22.1	70	25.3
Within workers' control:						
No reason	8	2.0	2/	.1	9	3.1
Absent	2	.4	2	.5	5	1.9
Breaktime	15	3.9	10	2.7	6	2.0
Miscellaneous 1/	3	.7	6	1.5	10	3.7
Total	28	7.0	18	4.8	30	10.6
Total	100	25.2	100	26.9	100	35.9

1/ Miscellaneous time was divided equally between outside control and within control of the worker.
2/ Less than 0.5 percent.

Approximately half of this additional delay time in conveyor warehouses is found in the "within workers' control" area and half in the "outside workers' control" area. In "outside workers' control" the areas of greatest influence appear to be "waiting for changeover" and "job reassignment." In the "within workers' control" classification the breaktime is reduced; therefore, the excess time was caused by the other classifications.

RELATIVE WAREHOUSE LABOR EFFICIENCIES

Some indications of the relative efficiencies of labor and in the use of labor can be gleaned from the preceding discussions. Major emphasis, however, was to show the allocation of the workers' time to the various materials handling operations. Up to this point in the study the best indicator of labor efficiency is the proportion of the workers' time spent in idle or delay time or, on the other hand, time spent in working. However, even this indicator does not give a complete picture because large differences could be reversed by the handling of different volumes during the time the workers are in a work status.

In this section, volume handled and worker efficiency ratings, while in a work status, will be considered along with the proportion of the workers' time spent in a work status.

Comparison of Rated and Work-Sampling Efficiencies

During the 3-day work-sampling study and the following time and motion analyses, each worker was rated as to his efficiency while performing his tasks. The overall operating efficiency of the warehouse group also was rated. Each of these ratings was reported in preliminary reports, prior to the analysis of the work-sampling study.

A significant difference is apparent between these two estimated ratings (table 19). The efficiency of the workers while busy at their assigned tasks averaged 99 percent for the 6 mills. The highest rated mill averaged 101 percent for all its warehouse employees while the lowest was rated at 94 percent. In making these ratings the typical worker was given a value of 100 percent with other workers rated above or below this normal level on the basis of their relative efficiency while in work status. Among all workers the highest rating was 120 percent while the lowest was 75 percent.

However, the overall warehouse operating efficiency for the 6 mills averaged only 70 percent. The highest rating was 75 percent and the lowest 60 percent. Since the efficiency of the workers is about normal when they are actually working, the much lower overall operating efficiency obviously is caused by delays and worker idleness.

The results computed from the work-sampling studies coincide closely with the figures of the rating for the overall efficiency of warehouse operations (table 19).

Attention is called to the fact that cleanup and other work is included as work in computing these efficiency ratings. A considerable portion of this type of work is frequently unnecessary and is only a means by which workers keep themselves busy when higher priority work is not available. Although a certain amount of cleanup work is necessary, the inclusion of such activities performed merely to "keep busy" does not give a true picture of the productive efficiency of the warehouse.

Table 19.--Relative efficiencies obtained from rating performance and work-sampling, 3-day studies

Classification	Fork-lift	Hand truck	Conveyor belt	Six mill average	Range in relative efficiencies: High mill: Type of operation	High mill: Percentage	Low mill: Type of operation	Low mill: Percentage
	Pct.	Pct.	Pct.	Pct.		Pct.		Pct.
Rated average when men are working	100	100	98	99	Conveyor	101	Conveyor	94
Rated overall efficiency of warehouse operations	73	73	65	70	Hand truck Forklift	75	Conveyor	60
Efficiency of warehouse operations from work-sampling studies 1/	75	73	64	71	Forklift	78	Conveyor	62

1/ Based on the time in work status.

The productive efficiency shown by the work-sampling study would be 72 percent for the forklift handling methods, 70 percent for the hand truck system, and 53 percent for the direct loading conveyor belt method, if the cleanup and other work was not included.

Work Performed in Work Status

The best available measure of work performed by the warehouse workers who used the various types of materials handling methods is the average tons or bags handled per man-hour during the 3-day survey. This computation was performed as follows:

(1) At the end of each 3-day study, 2 types of tallies had been accumulated; one, the number of trips the observer made through the observation points and the other, the number of total observations.

Dividing the number of observations by the number of trips resulted in an estimated "number of men employed."

Thus, if there are 567 observations and 90 trips, the estimated average of men employed in the warehouse during the 3-day study would be 6.3. This odd number of men results from the fact that the crew does not have the same number of workers at all times. Extra workers

may be added to load a rush order or some men taken away to handle rush work in another part of the plant.

(2) The total number of tons handled by the warehouse crew during the study of three 8-hour days is divided by the 6.3 average men operating to determine the "tons per man."

Thus, if 605 tons were handled, the total of tons handled per man during the study would be 96.

(3) Since three 8-hour days equal 24 hours, the 96 divided by 24 results in 4 "tons per man-hour"

Necessary Adjustments

Some modifications were required in order to make the data obtained in 2 of the 6 plants uniform and comparable with that obtained in the other plants.

One mill handled about 18 percent of its total tonnage in bulk form in tote boxes. This volume was handled and shipped by warehouse labor. Since all other warehouse crews handled only bagged feed, this volume and the observations recorded for this movement were not included. This modification makes the data for this warehousing operation comparable with the other operations.

In another warehouse an adjustment was made to counteract an unusual arrangement of warehouse facilities. 8/ After adjustment, the data for this warehouse can be compared on a reasonably equal basis with the data from the other mills.

Differences in Labor Efficiency

On the basis of the data gathered it is possible to calculate two additional basic measures of efficiency. First, the tons handled during a given period of worker time. Second, the tons shipped per unit of worker time. The tons shipped, however, can be unduly influenced by available orders during a short period of 3 days. Efficiency based on tons handled, however, is much more accurate especially when the types of operations performed are kept in mind. For this reason a majority of the material on efficiency will be based on the tons handled (tables 20 and 22) and the operations performed (table 21).

The two most meaningful items in tables 20 and 22 are the tons handled per man-hour and the bags handled per man-hour. The two items, man-hours per ton and man-minutes per ton, are merely different ways of expressing the same thing.

When total labor inputs are considered (table 20), the mill having the highest average tons handled per man-hour uses the forklift method. The low figure is the same for two mills, one using the hand truck method and the other

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8/ This mill had an augmenting warehouse some distance from the main warehouse and required more transportation time.

a conveyor belt. The average of the two plants in each category shows this same picture although the conveyor method has moved up somewhat into a second position.

Similarly the number of bags handled per minute shows the forklift truck as the most efficient and the hand trucks as least efficient.

When only worktime is considered, i.e., idle and delay time excluded, the picture changes considerably. The high mill used a conveyor belt. The hand truck, however, remains the least efficient. Considering the average of the two mills in each category, the conveyor plants become a close second to the forklift plants (table 22). Since the conveyor belt plants are relatively high,

Table 20.--Relative efficiencies based upon total labor inputs and product handled, 3-day average

Item	Unit	Fork-lift average	Hand truck average	Conveyor belt average	Six mill average	Range in relative efficiency: Most efficient mill	Least efficient mill
Tons per man-hour ...	Tons	4.2	3.0	3.4	4.0	4.3	2.8
Man-hours per ton ...	Hrs.	.238	.333	.294	.250	.233	.357
Man-minutes per ton .	Min.	14.0	20.0	18.0	15.0	14.0	21.0
Bags per man-hour ...	No.	167.0	109.0	127.0	151.0	169.0	90.0
Efficiency rating 1/	Pct.	74.8	73.1	64.1	70.6	78.0	62.0

1/ Work sampling analysis, time in work status.

Table 21.--Summary of specific operation performance, 3-day average

Item	Unit	Fork-lift average	Hand truck average	Conveyor belt average	Six mill average	Range of performance: High mill	Low mill
Bags per ton	No.	40	36	37	38	41	32
Number of items per day .	No.	30	33	27	29	34	18
Percentage of movement:							
Direct to shipping	Pct.	11	26	55	25	60	5
Direct to warehouse ...	Pct.	37	47	27	39	51	20
Direct from warehouse .	Pct.	52	27	18	36	54	16
Percentage of time spent:							
Manual handling	Pct.	49	39	47	45	56	32
Transportation	Pct.	26	34	17	26	38	18
Delay and idle	Pct.	25	27	36	29	38	22
Feed handled twice	Pct.	89	74	45	---	---	---

Table 22.--Relative efficiency based upon worktime inputs and products handled, 3-day average 1/

Item	Unit	Fork-lift average	Hand truck average	Conveyor belt average	Six mill average	Range in relative efficiency: Most efficient mill	Range in relative efficiency: Least efficient mill
Tons per man-hour ...	Tons	5.45	4.20	5.20	5.0	6.3	3.9
Man-hours per ton ...	Hrs.	.185	.239	.201	.209	.159	.256
Man-minutes per ton .	Min.	11.1	14.1	12.1	12.0	10.0	15.0
Bags per man-hour ...	No.	217.0	154.0	190.0	189.0	248.0	126.0

1/ Work sampling analysis.

when idle and delay time are excluded, and relatively low when it is included, it would appear that the efficiencies of the methods and the labor use must have some influence. An examination of the efficiency rating based upon the work sampling analysis tends to verify this deduction. Labor efficiency in the warehouses with conveyor belts is 9 and 11 percent below the hand truck and the forklift operations. If a warehouse using conveyor belts could achieve an efficiency comparable to that found in forklift operations, the tons handled per hour would be 6.1, well above the forklift output.

When the tons shipped per man-hour are considered, the conveyor warehouses shipped somewhat more tons per man-hour than the forklift truck warehouses. This potential measure of efficiency is, however, considerably influenced by the amount of shipments during the 3-day study and especially by the proportion shipped direct (table 21). The larger the proportion shipped direct or the less double handling required the more efficient any type of warehouse will become when the tons shipped per man-hour is considered.

Warehouses using conveyor belts, therefore, are somewhat less efficient in the use of labor than warehouses using forklift trucks in this approximately 100 ton per 8-hour-day operation, assuming that the conveyor systems studied were as representative as the forklift case study plants. This is especially true because the average bag sizes were about the same, the number of items handled per day were less, the percentage of bags handled twice was only about one-half as large, and 5 times as much feed moved directly into shipment as in the case of the forklift operations (table 21).

Inasmuch as the forklift method shows the most tons handled per man per hour, it appears that even in a situation favorable for direct shipping this method of handling should receive consideration.

It should be pointed out in this connection that the physical facilities of the warehouse in one of these conveyor belt operations contributed toward its low position. The 2-wheel hand truck operation seems to be the least

efficient of the methods analyzed in the volume and operating categories included in the study. The relatively low efficiency of the hand truck operation probably affects somewhat the combined average for the conveyor belt operation because one of these mills uses hand trucks in conjunction with the conveyor belt. The other uses forklift trucks and had a relatively high output of tons per man-hour but a very low efficiency rating for manpower use.

Causes for Difference in Labor Efficiency

It is significant that the comparative efficiencies of all the mills using the forklift and hand truck methods do not have a wide spread. The mills using the conveyor belt method, however, show a wider spread but both are relatively lower.

Study of the three handling methods shows that the forklift and hand truck methods are quite similar in their utilization of labor. A man takes a bag from a runout table and places it on a pallet or truck. He is generally required to stay near the table at all times.

In loading the shipping vehicle, a man picks up a bag from a hand truck or pallet and places it in a car or truck. Here again the two methods are similar. Slight variations of these methods do occur, of course. On using a hand truck, sticking and bucking the load is often employed. With a forklift, take-it-or-leave-it pallets are sometimes used.

Regardless of the variations, the labor utilization is similar in that only a small proportion of the warehouse crew is tied to the system delivering the bag from the packer.

In contrast to this, the conveyor belt method has the large proportion of its warehouse labor dependent on the delivery system from the packer. Since a large proportion of the lost time occurs at the takeoff position, it is obvious that the more men employed at this location, the greater the delay time.

As indicated in the idle or delay time discussion the main causes of lost time are changeovers, intermittent work flow, and waiting for previous operations. These delays occur most frequently at the takeoff positions.

With the direct loading conveyor belt, each loading position in use is the equivalent of a takeoff table. Since this will seldom be less than 2 locations, each having 2 men, at least when loading rail cars, the results of a delay in the system will affect 4 workers instead of the 1 or 2 that would be used as takeoff man under the other systems.

Also, the need to stay close to the takeoff position applies to all loaders instead of the man at the takeoff table. Consequently, the opportunity for using some of the delay time in other work is reduced.

Another factor, when the conveyor belt method is used, is the relatively high amount of lost time for changing assignments. Considerably more

nonproductive walking back and forth from one takeoff position to another was recorded. The argument in favor of the conveyor belt method is that it eliminates double handling. This is true and when varieties and shipping quantities are of a nature that very little feed need be carried as warehouse stock, the direct loading conveyor belt method will allow the workers to ship more tons per man per hour.

When compared with the forklift method, the elimination of double handling that results from the conveyor belt method apparently does not overcome the delays inherent in the conveyor belt method, at least at the shipping direct level analyzed in this study.

Some Observations on Bag Versus Bulk Handling

When the portion of a mill's output that is handled in bulk in tote boxes is included in the calculations, the average tons handled per man-hour is increased by 25 percent. Excluding idle and delay time, the tonnage handled per working man-hour increased by 23 percent.

On the basis of the average tons handled per man-hour, it would have required 29 extra man-hours to handle this bulk tonnage in bags.

Calculating the bulk tons handled per warehouse man-hour in the same manner as was used for bag feed, one man can handle 14 tons in one hour. This is 10 tons more per man-hour than the average for the 6 mills handling feed in bags. On this basis, it required 13 additional man-hours to handle this feed in bulk.

No labor is needed at the takeoff table and no labor is needed to place bags on the truck. The only warehouse labor required for handling bulk feed in tote boxes is the forklift driver.

It must be emphasized that the conclusions indicating that it required 13 hours to handle this feed in bulk as compared with an estimated 29 hours for feed in bags are based upon a comparatively few work sampling observations. In this mill, however, by adding 18 percent to the mill output and handling this in tote boxes rather than in bags, the tons handled per man-hour increased about 25 percent for the entire warehouse operation.

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